We are IntechOpen, the world's leading publisher of Open Access books
Built by scientists, for scientists

4,800
Open access books available

122,000
International authors and editors

135M
Downloads

154
Countries delivered to

Our authors are among the
TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index in Web of Science™ Core Collection (BKCI)

Interested in publishing with us? Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Chapter 5

Emerging Applications of the New Paradigm of Intelligent Decision Making Process: Hybrid Decision Support Systems for Virtual Enterprise (DSS-VE)

Gabriela Prelipcean and Mircea Boscoianu

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/3371

1. Introduction

1.1. Introduction in the paradigm of intelligent decision making process

In the aftermath of the recent global crisis, the modern firm should proactively respond to the disruptive changes in the dynamics of markets, new technologies and the new architecture of the competition. Shen, Norrie (1999) proposed the following set of capabilities for the next generation of production systems: the integration of the firm with all its management systems and their partners to better respond to the global competition and to the movements in the markets; distributed structure based on knowledge; heterogeneous environments (software and hardware heterogeneous distributed in the production and operational environment); interoperability opened and capable to integrate new systems in an dynamic way; efficient cooperation with suppliers, partners and clients, integration human-machine; agility (the ability to adapt to a new environment in the case of rapid changing); scalability (additional resources could be easily incorporate) in every point location at every level without affection to the inter-organizational interdependencies; a good tolerance to different types of errors.

In real word it is very difficult to change, to adapt and to innovate in the context of a centralized managed process. It is necessary a new paradigm of intelligent decision making, more generalized, more flexible, more adaptable to change. The classical decomposition in subsystems- elements is not effective and the distributed method, which defines the components and the interactions between components in order to analyze the effects of dynamic interaction, is better in this emerging context.

It is necessary to adopt new methods, new technics and new instruments for decision support capable to:

- structure and enhance decision-making meetings (intelligent decisional planning);
- facilitate communication between decision-making factors and structuring decision-making problems (decision charts, decision trees);
- online analysis of the data and extracting information and knowledge using Data Warehousing (DW), Online Analytic Processing (OLAP), and Data Mining;
- assess the effects of application of alternative decision-making (what-if) using simulation techniques;
- construct and recommend the optimal decision-making alternative using multi-criteria optimization techniques;
- recommend a candidate solution by multi-attribute decision making (MADM);
- suggest decision-making alternatives based on artificial intelligence (expert system ES, artificial neural networks ANN, Case based reasoning CBR, Genetic Algorithms GA, Swarm Intelligence SI or hybrid models).

2. Decision support systems

The decisional support signifies a set of procedures based upon mathematical models on processing data, in the view of assisting the manager on taking decisions in conditions of simplicity, robustness, controllability, adaptability and completeness (Little, 1970). The Decision Making Process (DMP) consists in the outcome of decisional activities carried out by the representative taking decisions, assisted by a decisional team on supporting and/or a Decisional Support System (DSS). According to Nobel Prize laureate H. Simon, the DMP includes the following tasks: informing and up-taking of information, in order to formulate accurately the decisional issue; designing (includes activities in the view of understanding the decisional issue, adopting a new type of running, generating some new potential action ways and building the models); selecting the alternatives and adopting the solution; implementing the decision and evaluating the involvements. The activities and the phases in the H. Simon model emphasize a generic character and cover a large series of situations. The content and ampleness of them depends upon the decisional issue's features and upon the approaching way that was adopted in the view of solving the issue.

2.1. Basic elements of the DSS concept

DSS should cover a significant number of activities and phases of the decisional process. DSS is running in coordination with other components of the global informatics or informational system of the organization, where data or information is transferred. The available Information and computer technologies, ICT, and the designing and implementation

http://dx.doi.org/10.5772/3371

methodologies play an important part within the quality of the chosen solution. The accurate and equilibrated admixture between those three technologies (computerized models, databases and friendly interfaces) signify the technological centre of the DSS.

The typical constraints of a DSS are: a facile user's control adaptability to certain situations / user's characteristics, as well as the level of use during the process of decisions issuing. The controllability refers to the possibility of using the system at any moment and respectively, the possibility of changing the course of running in accordance to the own wish. DSS should be flexible enough to adapt to the deciding representative; by providing trust, the DSS leads towards a synergic evolution of use, in conditions of customization. Agility represents the capability to change and adapt quickly to changing circumstances. Using DSS is intended to support all phases of the decisional process.

Building a DSS starts with the participants (issuers of instruments, building analysts and the end-users), as well as the context elements (the current situation and the changes estimated in the context of the ITC progress) that interact with the organization. In this process, the specialists and end-users participate (analysts, designers or issuers of DSS instruments), working together within a team assigned by DSS. The DSS team will know details about the own products, as well as the competition alternative products; as regards the success of conception, building and implementation of DSS, the following conditions should be met: a better knowledge of the application, access to the knowledge sources, the identification of challenges of decision making process in connection with the end-users particularities, restraining the information instruments and accurate methods for designing an efficient DSS. The DSS team should provide as faster as possible an employable version and easy to adapt on the technological changes.

2.2. The DSS components

DSS is formed of four essential subsystems: the language subsystem, LS, which emphasizes the set of expression forms, by which the user can transmit; the subsystem of presentation, PS, that signifies a set of forms or means by which messages are transferred (from out to DSS) towards the user or third parties (executants of decisions, data sources within organization); the subsystem of the knowledge elements, KES, which includes elements of knowledge purchased or created internally; the subsystem of problem solving – PSS, signifying the set of software modules by which the KES knowledge elements are processed, as result of rendering the input messages. The amplitude and characteristics of these four subsystems and the adopted solutions of information transposing can make a difference between the application systems.

2.2.1. The Knowledge Elements Subsystem – KES

KES includes the knowledge, whichever the user hasn't any ability or time necessary to accumulate it. KES has the mission of simulating the general knowledge volume, specific to the application and decisional situation that an ideal decisional assistant should have.

The primary elements of knowledge are useful on recognizing a decisional situation and serve as “basic material” in order to issue a solution. These can be particularized into the following classes: descriptive knowledge, procedural knowledge (mathematical knowledge of simulation and optimization, as well as the algorithms of the associates solving the issues), the knowledge regarding the reasoning (concerning the governmental rules and justifying the way of using the procedural knowledge simultaneously with those descriptive).

The secondary knowledge elements (linguistic, which serve on understanding the signification of users solicitations, and of potential reports from the decisions executors, or from other data providers; of presentation which describe the way information is sent during the decisions issuance, or eventually, decisions are communicated; assimilative, which use on determining the conditions and on establishing the way the new knowledge elements can be inserted into KES), aiming on supporting the activities of issuing decisions by auxiliary activities, such as: interpretation of the input messages (received from users or third parties); illustration of the output messages issued by the system (towards the users or third parties); maintaining and updating KES. The knowledge stored is characterized by the following: the source (outside DSS or inside the system), specificity (general, applicable to a field, or strictly related to an application), the persistence and completeness (one or more amongst the types of knowledge elements).

2.2.2. The communication subsystem

The communication subsystem can include many solutions in order to take into consideration the following: knowledge and the cognitive style of those interacting with the system and the part these have towards the system (user, manager or data provider). A compromise should be carried out between simplicity in using, and respectively efficiency and performances.

2.2.3. The problem solving system, PSS

The PSS signifies the dynamic part of DSS, which carries out the knowledge processing, and includes the software programs that transpose the processing knowledge capacities (purchasing the knowledge; selecting the already existing knowledge elements, necessary as basis on issuing the decision and issuing new achieved knowledge; presenting the results; managing and updating the KES content).

2.3. An analysis of the possibilities of selection DSS architecture

The DSS- data oriented decision structure (DSS-DO) is focused on the apprehension and diagnosis of decisional issues, identifying the action alternatives and checking the new hypothesis and ideas. The main particularity consists in organizing the knowledge elements subsystem under the form of well structured databases, which sometimes might have significant dimensions. The PSS is transposed in information by means of the software modules, which carry out the data management, the interactive finding of information and various processing, specific to particular applications.

http://dx.doi.org/10.5772/3371

The support subsystems of documents oriented decisions (DSS-DO), based on the descriptive, procedural or reasoning knowledge use serve both the information decisional activities, as well as the activities of evaluating the action alternatives and choosing a solution. The focus is on the abilities of managing the electronic documents and developing the knowledge, and the interest is to realize the classification and indexation of documents.

The support subsystems of models oriented decisions (DSS-MO) appertain on offering solutions on solving the decisional issue model. The set of solution is directly included in its executable form within the logic of the software modules, transposing the subsystem of issue solving, by means of informatics; or, the set of solvers is kept under the form of programs library, that can be modified in the collection of procedural knowledge of the knowledge elements subsystem. The user can modify parameters/ data and can specify the paths of calculus. The flexible solutions allow the selection of the solving algorithm, defining the presentation way, the modification of the algorithms collection. In contradistinction to the data oriented systems and those oriented on documents, the DSS-MO include a relatively reduced volume of descriptive knowledge elements.

Regarding intelligent DSS (IDSS), the focus is on storing, managing and processing of knowledge on reasoning, within the system of knowledge elements, by using the engine of interfaces carrying out, which can be implemented into the system of treating issue. Initially, the knowledge oriented systems were aimed on replacing the models oriented systems, in situations where no enough truthful model could be issued in order to solve the decisional issue, or in situations where such model were too complicated so as to be solved by the help of the already existing algorithms.

The knowledge elements concerning the reasoning and the software modules based on artificial intelligence, and which implement the abilities of processing such knowledge, are seen as an ingredient within the combined structures of the DSS. In this case, the reasoning knowledge can play different tasks: the intelligent processing of the messages expressed within a non-procedural language, the management of other types of knowledge included into KES, using the procedural knowledge within the evaluation and selection of the solution, at the level of human expert competencies.

There are more styles of mixing the systems, by means of integrating the software modules that transpose by the help of ICT the capacities of knowledge processing, and respectively, those referring to communication inside the same informatics instrument. The styles that characterize the integration within various information instruments are the following: a) integration by knowledge conversion (interfacing) or the endowment of the software modules that should communicate with facilities embedded by knowledge export; b) integration, by means of the clipboard memory; c) integration, by means of the common formats.

The patterns that define the integration inside the same information system are: integration by nesting, where one or more software modules are embedded within a single “host” prevailing program; the synergic integration, situation when more knowledge elements represented in various forms can be processed.

Within the context of the combined systems, calling up the classical paradigm of DSS based on tripe structure of components can be useful: dialogue, data or models (DDM). This is an example of combined data and models oriented system, covering a part of the support possibilities for decisions allowed, thus enabling the DSS decomposing in subsystems, and in completing or endowing with new modules, respectively.

2.4. Aspects regarding the construction of DSS architecture

2.4.1. Stages of creating a DSS process

Creating a DSS includes a series of activities that start with generating of the idea on introducing the system within an organization, and ends by achieving the prototype: preparing the projects, the system analysis, designing, implementation and exploitation. The DSS architecture is determined by elements, such as: the central element aimed in the process of building the DSS architecture; the information platform used; the DSS builder; the form of the process (linear, based on the stages of life cycle or in cycles using the prototype); the interaction between the technical processes and those social that took place while creating an DSS.

First of all it is necessary to mention that the idea of introducing a DSS has determined a series of strengthening activities, in order to be transformed into a first specification of the future system (the diagnosis of current situation, establishing the main characteristics of the future system, evaluation of feasibility and design planning). The diagnosis consists in identifying the current issues and presenting the opportunities, as well as the means of changing or improving, respectively. The commitment decision and the resources allotment follows, in accordance to the feasibility study, framing the project within the development politics is taken into account, as well as the company's priorities, the harmonization with the ICT infrastructure, the availability of funds within context of justifying the impact over the organization and preliminary risk management issues. Planning the project includes the orderly list of phases that follow to be developed forwards: the system analysis, the design and implementation, as well as the potential activities of maintenance. For each stage are indicated: the moment of start/ end, the expected results, the responsible persons and the other participants, as well as the allocated resources.

In the system analysis stage, it is necessary to mention data storing and processing, take into consideration the following: the stock-taking and thorough studying of the decisional situations, for which providing the information support is aimed; discovering the particularities of each individual that will become users of the system; identification of some frame elements, such as: the restrictions introduces by the organization in issuing, transmitting and executing the decisions, the existing information infrastructure and the possibilities of combining with other parts of the global information system of the organization; the evaluation of results, of the previous initiatives of introducing the DSS in that organization or from others similar, in order to avoid some potential signalized errors.

The technical design should take into consideration both the ground system, as well as its components as regarded from ITC point of view, the content of defining specifications is transposed into an execution project. The designing process is composed of activities of establishing the DSS structure and of defining each technological component of the system, as well as the way it integrates with the other parts of the global information system of the organization. The designing stage is accomplished by the specification of carrying out the system and integrating it within the organization. The level of describing in details and of defining the components depends upon how this is allowed while using information platform. For most of applications, the component where the designer has the most levels of freedom signifies the data basis, followed by the dialogue subsystem.

In the stage of implementation, the content of technical design is transposed into an information system, by means of the instruments selected, and consists in activities of effective building of DSS into an application and integration within the global information system of the organization, testing and issuance of the documentation, of building the future users and taking organizational measures, necessary to effectively exploit the system. Testing the system by the user is necessary in order to see the way the system carried out will satisfy the direct future beneficiary. This represents the validation of user, named also as acceptance test or operational test, and is able to determine the modification of characteristics.

The exploitation and the progress of DSS are important because the efficiency and the costs on the entire life cycle of the system are essential aspects. The validated system in action is provided with documentation of using and maintenance issued, and can be carried out in current exploitation. The further modifications of the tasks, preferences of users can determine the need of adapting and modernization of the DSS.

2.4.2. The DSS generator

The selection process and the effective use of a DSS generator will influence powerfully both the solution achieved, as well as the way one can reach to it. Within the system analysis, a stock-taking of the DSS generators already existing on the market is aimed. These are selected by means of a limited number of criteria, in the view of filtering those not serving on reaching the requirements included within the functional specification of details, that do not frame within the restrictions imposed by the already existing information infrastructure or in the strategy of developing the global information system of the organization, or that lead towards the unacceptable overreaching of the project budget.

The next stage is placed into the stage of issuing the technical project, when the alternatives selected in the previous stage should be put in order, in the view of performing a selection. In order to solve it, the following became necessary: defining the set of evaluation criteria and of weights associated to them, appreciating the value or the utility of each instrument-candidate, viewed through all the evaluation criteria and applying a method of establishing the classification.

As regards the ordering, a set of evaluation criteria will be used: the completeness, which means that per assembly, the criteria should cover all the issues that can slope the balance towards an alternative or other; the non-redundancy, which imposes a certain issue to be taken into consideration, only by a single evaluation criterion, so that more calculations will not be carried out in a favorable or non-favorable way; the discomposing, which requires that a criterion, seen as general or vague, might be decomposed in more simple independent criteria; the operability, which shows that formulating the criteria should be expressed very clear, in order to be understood by all involved on taking decisions and choosing a solution; the minimalistic feature, consisting in the drawing a limit for the criteria number, so as to solve a dilemma between a fast but superficial analysis, and one that can become non-opportune, because of the attempt on taking in view another perfect solution reaching.

The DSS generator can be used in order tot test some requirements or ideas of designing, which were unclear from the start of the project, and in order to simulate the future user's interest, and of convincing the project's sponsor, after which designing an optimized and flexible system will be carried out by using primary constructive elements. In this way, the DSS generators are ideal means on building a progressive and based on prototype structure.

2.4.3. Data management in DSS

In order to achieve efficient results, quality data, well-structured and organized has become necessary. The set of attributes that characterize the data quality is different from one type of information system to another. In this way, the systems necessary to control in real time the technological processes or to enable fast data access signify the most important feature, while high data precision within computer aided applications is compulsory. The main data models are: the hierarchical model, the network type model and the relational model. Starting from the very beginning, some issues that might occur within a DSS could be identified, being caused by weak quality of data: the necessary data on issuing the decision does not simply exist, since none has thought that such data might be necessary; as consequence, it should be stored; the already existing data within the system are not accurate or are old; data gathered in the system are not consistent with the way of performing activities on issuing decisions, where decisions are being represented accurately. The data storage signifies the name of a specialized database, aimed on satisfying firstly the information necessities of the top managers or of the workers based on knowledge, which develop activities of strategic type within an organization. The data included within the storage come from multiple and various internal and external sources.

The main classes of operations are drawn up by: data storage by its extraction from various sources; the data conversion from the original format into the adopted format, in order to be used within the data storage; ordering the data, by identifying and correcting the conversion errors, and by completing the omissions; the internal derivation of new data from the operative data received and processed, by means of aggregation or synthetizing actions, so that the data storage can include elements that haven't been met within the operative databases; effective loading into the chosen data structure, in order to be used in subsequent interrogations and analysis.

http://dx.doi.org/10.5772/3371

2.4.4. The portfolio of models used within DSS

DSS models can be classified in accordance to the following criteria: the aim, the time variable existence, the certainty degree, the generality, the decisional level and the issue type, in this way, the aim can signify: the understanding of decisional situations, the consequences of applying the decisional alternatives and the robustness of recommended solutions.

Depending upon the presence or absence of time variable within the models form, these might be dynamic or static, respectively. Depending upon the certainty degree, deterministic and probabilistic models can be distinguished. Regarding from the generality point of view, a model can be used for a class of decisional issued or only into a single application. In accordance to the decisional level the strategic, tactical and operative models can be emphasized, on assisting and establishing the objectives and necessary resources on log terms. These are, in generally, descriptive, dynamic, deterministic and created accurately, being provided with a high number of generating variables.

Within a DSS, more models and associated solvers can exist. As in the situation of data, models signify one of the sources with organization knowledge elements. In order to manage and exploit them, without being known by the user or the application programs and without the need of explaining in details the physical aspects relative to storing the models, the existence of a management system for the portfolio of models capable to execute tasks analogous with those specific to a databases management system. The characteristics of this Models Management System (MMS) emphasize the existence of some accurate control means, for both the expert user and the new one; the flexibility or possibility of choosing or changing the preference towards the model type during the decision al process; the presence of the reaction able to indicate the stage of developing the models execution, the compatibility with the solutions chosen for the system of databases management system.

The main functions of the MMS refers to the abilities of performing the assimilation of procedural knowledge on designing and selecting, in the view of exploitation, in order to process descriptive knowledge elements, such as: creating some models in the view of storing them within the DSS models database. Creation and assimilation of new models can be accomplished in more ways, meaning: selection performed in the view of storing new models from the set of the already existing products on the market, formulating new models, by the help of designing languages and using the issue's characteristics, the content of some complex models from the already existing building blocks and by integrating building modules, similar to the content, but foregoing by the operation of modifying modules; maintenance of the models base by updating and extension actions; selecting and preparing, in the view of executing the existing models and the algorithms of solving, so as to assist the activities on decisional issues solving; the execution of models and data sets, followed by the evaluation of results and potential taking over other data sets.

All these assume the existence of more elements, such as: a language of designing, aimed on ensuring the creation and loading of models within the models base and by the help of solving algorithms; models database and solving algorithms easy to be accessed; a diagram of treating the models and algorithms, enabling the selection in the view of execution.

2.5. The integration of artificial intelligence (AI) in DSS

In order to increase the decisional performances, DSS can be endowed by means of artificial intelligence techniques. The artificial intelligence techniques are used for both information processing and data visualization, as well as for extracting the information from high data volumes, in the view of searching templates that might be helpful within decisions taking processes.

The Artificial Intelligence (AI) is characterized by a high learning ability, in the view of continuous improvement with or without external helping. The main applications of the AI are the following: the expert systems, the neuronal networks, the logic fuzzy, the genetic algorithms, the intelligent agents and pattern recognition. Programming languages have been especially created, such as LISP and Prolog, in the view of carrying out the research in the field, and even on creating artificial intelligence devices or programs.

One of the candidates to be incorporated in the intelligent decision making paradigm is the intelligent control (Fu, 1970) with the aim to reproduce the most important human intelligence characteristics (adaptation, learning, planning in uncertainty environments) and the capability to interpret a huge quantity of data. Based on the new approaches (artificial neural networks - ANN, fuzzy logic - FL, genetic algorithms - GA, expert systems and hybrid systems), DSS could be reinforced via the biological inspiration (Swarm Intelligence, SI) and could solve an extended category of applications.

FL shapes the rationing of human brain based on the approximate, non-quantitative, non-binary reasoning. Applying the FL method is performed in the following steps: defining the input-output variables, defining subsets intervals, choosing the functions, setting the if-then rules, performing calculations and adjusting the rules.

NN tries to reproduce the structure and functions of the human nervous system (consisting of a large number of interconnected neurons that determine the way in which the information is stored). In ANN the neurons receive inputs from other neurons through a weighted function (with increasing / decreasing signal). These signals are received and collected by the neuron, and if the amount exceeds a certain threshold, the neuron will send its own signal to other neurons. Information is stored in the neuron input weights and the adjustments offer the ability to store different information. The storage capacity of a single neuron is limited, but the set of neurons interconnected in several layers provide superior performance. ANN are used to solve problems of estimation, identification and predictive or problems of complex optimization. Due to independence of operations inside the components, related models have a great potential for parallelism.

Based on the Darwin's principles of genetics and natural selection, GAs are adaptive techniques for heuristic search (Holland, 1975). The biological process of evolution is based on the adaptation to the environment, the capability to survive/ evolve over generations. GA is a complex model that emulate biological evolutionary model to solve/ optimize problems. It includes a set of individual elements represented in the form of binary sequences (population) and a set of biological operators defined on the population. With the support of operators, GA manipulates the most promising sequences evaluated according to an objective function and improves the solution. GA are used to solve optimization problems (near-optimal solutions), planning or search problems.

The AI has studied new architectures of computing, able to: offer support in situations of unclearness and uncertainty; to use knowledge and the experience on adapting to the environment changes; to understand, to deduce and to analyze new situations; to recognize the relative significance of various elements in the context of fast changing of situations or to detect the ambiguous or contradictory messages.

In the view of achieving an intelligent machine, such amplitudes concerning the intelligence and related behaviors or mechanisms should integrate within the computing system. The intelligent system should be able to offer a fast, soft and adaptable support, endowed by the ability of acting accurately within an uncertain and chaotic field (Meystel, Albus, 2002).

AI based technologies are able to establish both an alternative to the numeric methods, when these fail or cannot be applied due to the qualitative issues preponderance and uncertainty presence, as well as a complement of them, when the limits above mentioned can affect the decisions quality.

The limits of the AI based technologies should be also taken into account. For example the solution could be sensitive to decider's preferences and there is a limited ability of treating small variations of the attributes, with impact on the experiments (since the user does not have access to rules within the knowledge base). There are also technical difficulties specific to various means of knowledge representation and the transmission of the parameters between the software components that implement the numerical methods, and those including the AI components. One of the most known AI based information technology met within the frame of decisional activities assistance is represented by the expert systems (ES). The differentiation between the DSS and ES can be expressed by: borders of the application field, which are evasive and many times variable and unpredictable in the situation of DSS, and limitary and well shaped within the ES; the historical progress that took place, since the beginning of real applications on carry out systems within DSS, respectively, from the study of abstract reasoning, in the attempts of creating some general systems of solving issues within ES; the normative, which is more pronounced within ES; the goal aimed, which consists in increasing the decisions efficiency on DSS and respectively, on growing the efficiency within the process of ES solution achieving; the user's attitude towards the system, which is of acceptance or rejection of solutions and explanations, based on the best knowledge within ES. An ES will usually designate an AI based information technology, while and DSS will involve, more often the idea of an application.

3. Virtual enterprise VE and virtual organization VO

3.1. Definition of concepts

The enterprise modeling is a complex process of building integrated systems of models (process models, data models, resource models) dedicated to the managerial support of a modern firm (Vernadat, 1996). In Petersen (2000), Bernus (1996) is proposed the Enterprise Engineering and Enterprise Integration concept (EEEI), useful in the actual context of a high competitive environment. In Fig 1 is presented the evolution of enterprises in the context of modern partnerships, based on the VE/ VO concepts.

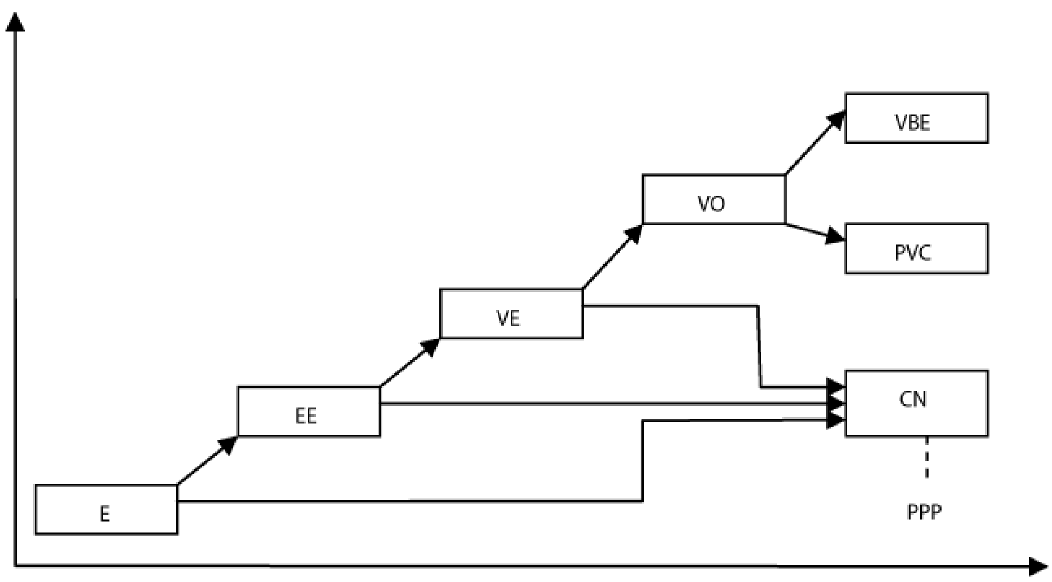

Figure 1. The evolution of enterprises and modern partnerships (based on the VE/VO concept)

The concept of Extended Enterprises (EE)/ Extended Enterprise Engineering (EEE) is often used in the context of virtual enterprise (VE) as a partnership and involves constructive collaboration between the manufacturer, the customer and the supplier. EE is a formation of co-operative enterprises responsible for all operations related to the product (from procurement to end customer, but it also includes maintenance/ service tasks). In Vernadat (1996), there is no distinction between EE and VE, which function based on a cooperation and the use of ICT communications and electronic data interchange, but in Globeman (1999) is proposed a clear distinction based on their lifecycle characteristics. In this case EE is a network for collaboration which offers share core competencies and becomes operational after a specific customer demand via the building of a special purpose vehicle (SPV) named VE. Enterprise Integration (EI) is a holistic approach that provides frameworks and methodologies to integrate complex systems. Totally Integrated Enterprise (TIE) is an extended architecture and taking to consideration the entire customer/ product life cycle. The modern paradigm is related to the collaboration/ partnerships in the context of competition. Collaboration between different types of partners offer opportunities (a better market share, stock reduction, cost reduction, better quality, shorter product development cycles) and enables partners to gain knowledge (innovation, a better understanding of the transformation of future processes/ markets, capability to implement efficient programs/ products). Specman (1998) proposed the transition from coordination to collaboration and Slack (2004) underlines importance of trust, commitment and information sharing among partners. SAP (2002) proposed the conceptive of Adaptive Supply Chain which represents a chain able to have better

http://dx.doi.org/10.5772/3371

visibility of requirements and capabilities in the context of flexible, adaptive and robust management, based on a greater speed of information and assets.

There are different definitions of the virtual enterprise VE/ VO concepts. The VE emphasizes a temporary alliance between enterprises, based on cooperation/ partnership and efficient common use of competencies, abilities and resources, capable to respond to business opportunities or to improve the global performances. The VO also signifies an alliance between various organizations, but the objectives are extended beyond the simple profit achieving. According to Katzy (2002), VE is based on the ability to create temporary co-operations and to realize the value of a short business opportunity by using the synergy of the different capabilities of the partners. In Jagdev, Browne (1998), VE is defined as a temporary network of independent companies that are linked using information technology; the focus is on the technology that links the partners rather than the roles of the independent companies. In Byrne (1993) VE is defined as a temporary network of independent companies formed to share skills/ costs and to gain the access to each other's markets. In Garita, Afsarmanesh (2001) VE is represented by an interoperable network of firms that collaborate via ITC elements in order to realize a common objective. In Olegario (2001) VE represents a temporary alliance of independent firms with complementary competencies. In the DAI context, VE is a temporary, cooperative network based on independent, autonomous firms that cooperate in order to exploit a particular market opportunity (Clements, 1997; Fischer, 1996; Oliveira, Rocha, 2000; Ru, Vierke, 1998). Other authors incorporate properties of VEs such as "rapidly configured, multi-disciplinary network of firms" (Ambroszkiewicz, 1998), goal-oriented behavior based on cooperative work (Oliveira, Rocha, 2000), decentralized control of activities, (Szirbik, 1999), and commitment among the autonomous partners (Jain, 1999). The aim of VE is to provide a quick and flexible solution for an unpredicted opportunity. This agile reaction it is more than an action, rather than an institution. The focus is on the agility and adaptability to grasp a new opportunity and it is based on quick innovative solutions. It results that the concept of VE is linked to the following attributes: value created and not added; there is only a temporary cooperation focused on objectives; there is a mechanism capable to facilitate permanent restructuring in flexibility, adaptability and robustness.

Regarding the VO concept, in Davidow, Malone (1992) the interest is to integrate the information throughout the organizational components and to act intelligent based on this information. In Venkatraman, Henderson (1998) VO is based on the "virtualness" strategy with three independent components: virtual encounter (customer interaction), virtual sourcing (asset configuration) and virtual expertise (knowledge leverage). In Fox (1998) VO is defined in the context of strategic alliances.

The Virtual Breeding Environment (VBE) represents an extended cooperation between organizations (cooperation agreements, common operation principles and a common infrastructure), in the view of identifying new opportunities in order to build temporary alliances, able to lead towards achieving better results on mean and long term. The Professional Virtual Community (PVC) combines those virtual community concepts (individuals' networks that uses computer technologies) and professional community (pooling the experience, knowledge and competencies).

In the literature (Camarinha-Matos, Afsarmanesh, 2001; Camarinha-Matos, 1998), there are presented different types of classification for VEs according to the following aspects: duration (lifespan of the organization); the topology of the network; the flexibility of the structure; the level/ type of participation (a partner could participate in just one VE or several VEs simultaneously); the type of coordination (centralized coordination, democratic alliances, federation of partners) where the partners achieve their goals by creating a joint coordination structure; the visibility scope (related to typology and coordination/ dependencies among the partners).

Other authors (Bernus, 1997) identify several different types of VEs: major/ huge scale projects; consortia (for production, research or service as an alliance of partners limited to a common mission); general project group (set up by business executives).

Regarding the main characteristics/ properties of VE we should mention there exists a partnership of organizations that collaborate or a strategic alliance (the partners are aligned at the activities level, but also at the level of their business goals); there is a temporary network with a limited lifetime based on the exploitation of a particular market opportunity or a special customer demand; high level of communication based on advanced ICT technologies capable to support the entire partnership; dynamic sharing of skills, costs and markets; goal-oriented and commitment-based. Wigand (1997) identified the main characteristics (modularity, heterogeneity, time/ space distribution, open-closed and transparency) and the corresponding design principles. Goldman (1995) identified the following characteristics: opportunism, excellence, technology, no borders, and trust. In the modern literature, other authors (Tolle, 2004; Camarinha-Matos, Afsarmanesh, 2005) concluded that the more important characteristics of VE are: a partial mission overlap; customer-centered and mass customization; network of independent companies; semi-stable relations; geographical dispersion; focus on core competencies, and innovation. The recent evolutions demonstrated also the following characteristics: single identity; based on trust; shared loyalty; focus on the use of ICT; the management should understand the essential distinction between strategic and operational levels; capability to stimulate/ integrate innovation.

3.2. Possibilities for evolution and developments

At the foundation core of VE are the proactive exploitation of dynamic competition rather than the transformation of raw material into finished products. In the traditional view, value is created in the form of labor performed and resources consumed both of which can best be achieved under stable conditions (Norman, Ramirez, 1993). In contrast, the VE/ VO are a structure that supports entrepreneurial innovation to create new platforms from competencies, resources and partners that have never existed before. In this case the value is created from new opportunities and new structures should be implemented in order to exploit these opportunities.

In Fine, Whitney (1996) the evolution and the development of VE is linked to outsourcing/ subcontracting features, with focus on the core capabilities by deciding whether to make/ buy a given component/ subsystem. Another branch of literature (Jager, 1998; Wildeman, 1998; Franke, 2001; Tølle, 2004; Camarinha- Matos, Afsarmanesh, 2005) considers VE as an evolution from network organizations with creative combination of attributes from outsourcing, strategic networks and agility.

To understand new opportunities, we first examine potential sources of value identified in the empirical literature. We then discuss virtual operations as a temporary industrial structure designed to exploit these opportunities.

In Figure 2 is presented an intuitive, but practical way for developing a VE solution based on the identification of needs in a context defined by environmental factors and restrictions. The interest is to enhance the capability to respond to different opportunities of the markets by stimulating organizational flexibility. In Figure 2 it is also a suggestive picture that represents the way to model and integrate the VE operation in real business until an efficient decommissioning, coupled with a reliable capacity to recuperate units/ subsystems adaptable for future VEs. This is not a standard form, because VE/VO required an architectural construction and it is a complex innovative process.

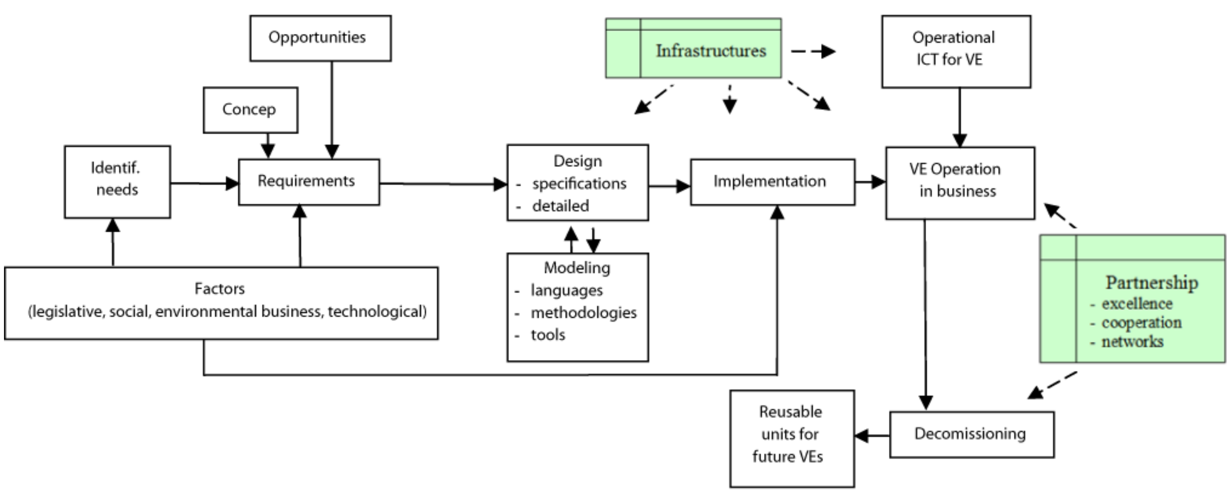

Figure 2. The practical way for developing a VE solution

3.3. Possibilities of modeling VE/ VO architectures

Agent based modeling (ABM) is a more powerful concept better adapted to the actual trends than the classic process of equation based modeling, because the complexity could be modeled by using the interactions between the elements- subsystems. Multi agent systems (MAS) are characterized by: modularity, decentralization, interchangeability, low structured character and complexity. The most interesting applications of ABM/ MAS in production management are represented by SCM (supply change management), addressed to offer better services to clients with lower production costs and VE/ VO which represents a unique interconnected chain of the supply in which the activities realized are oriented to the objective of production. VE/ VO mix the advantages of integrated firms (financial power, availability of resources, production costs) with the advantages of distributed firms (adaptability, flexibility). From the perspective of MSA, VE/ VO represents a group of agents which cooperates in order to realize a unique objective.

Regarding the state of the art in the field of formation/ operation of VEs (Kazi, Hannus, 2002; Zweger, 2002) we should mention different types of architectures which support the formation and operation of VEs and capable to optimize the cooperative functioning of the key components of VEs such as elements that support modeling, set up management, ICT support, reference models, and infrastructures, like GERAM (Generic Enterprise Reference Architecture and Model) and Virtual Enterprise Reference Architecture and Methodology (VERAM).

The modeling of these types of architectures are based on the following features: the lifecycle view (the phases in the lifecycles); genericity (generic, particular and partial levels); modeling strategies (a view which comprise function, information, organization and resources).

The basic steps in the life cycle of a VE are: preliminary configuration of the VE and design phases of the lifecycle; the build of a detailed design and implementation of the phases in the lifecycle; service/ maintenance; decommission VEs during the decommission phase of the lifecycle.

The phases of the development of VEs (Parunak, 1997) are: creation (establishes the goal/ objectives of the future VE according to the market conditions); management/ operation (focused on how to achieve the goals/ objectives); dissolution (ending the relationship among partners and evaluation of the results of this partnership). The design of VE could be divided in four stages: identification of the market opportunity; identification of the core competencies required for taking advantage of the market opportunity; the selection of the partner companies capable of delivering the required core capabilities, and the formation of the VE by operating an intelligent integration of the core capabilities of the partners. In Tolle (2004) the design is subdivided into five phases: identification, concept, requirements, preliminary design and detailed design.

4. Decision Support Systems for Virtual Enterprise (DSS – VE)

A typical DSS-VE system should contain tools, applications and models that can be efficiently used during the formation and operation of VEs but also courses which offer guidelines that indicate how these tools, applications and models should be used in practice (Zweger, 2002; Tolle, 2002). The main subsystems are: modeling (analyze, preparation and (re)-design of the VE's business processes, partner roles, contracts); applications and infrastructures (the components that perform or support the processes in order to provide the technological realization of the VE); methodology (guidelines on modeling); contingency factors ("situational factors" or conditions which affect the set up of the VE and "design parameters" which describe different set- ups for VEs). Other authors have proposed software agents and DAI in order to support the dynamism of VEs, for example multi agent systems (MAS) for SCM (Fox, 1993)

The Distributed Business Process (DBP) is represented by a set of business processes (BP), which emphasize the VE. Since one assumes that BP is carried out by various enterprises, the entity that has started the VE occurrence will coordinate the accurate and efficient functioning of the new business (Rabelo, 1996). In this case, VE signifies an optimal supply chain management (SCM) equipped with extended possibilities of analyses: a better response in the situation of a reduced level of coordination that covers activities carried out on the production flow systems, capable to react; in the situation of a mean coordination level, which emphasizes advanced coordination functions or high level of coordination (based on intelligent coordination functions).

The VE coordinator should understand the aims and capabilities of each enterprise involved, but also the interconections. The new logistics imposed by this new architecture has determined the transformation/ evolution of the logistics toward an integrated flow of materials/ information that should be managed as a single entity, starting from the raw material up to the final consumer. Using the Integrated Logistics (IL), as a basic concept needed to meet the distributed relationships requirements, permits a better understanding of the involvements into the real integration of VE because it focuses on the global level of performance, and not on individual performance (Christopher, 1994; Moeller, 1994; Slats, 1995; Bowersox, Closs, 1996).

The VE functioning can be affected by the occurrence of some unforeseen, but critical events, such as: delaying or modification within the BP chain, changing the BP priorities, communication deficiencies and/or network overloading or falling. In the case of such a critical event, the VE coordinator should take all the measures in order to solve quickly the issue locally, and if such aspect is not reached, the coordinator will not comply with the provisions foreseen in the DBP contract; in this way, a conflict will occur, with impact on the information on DBP, thus affecting the entire production chain. The DBP assumes the existence of interdependencies between subsystems in order to take into account the entire network.

Depending upon the issue's seriousness, the solution might need more throughout and complex analysis. It is essential to take into consideration more evaluations and more factors, especially if we think that usually, an enterprise can carry out more DBP contracts, which can be indirectly affected by the BP under discussion. The complexity of a VE will make almost impossible the individual solving of each issue by a user, meaning that a single user will not have the necessary knowledge and capabilities (regarding from the necessary time and technical experience point of view), or solving each issue by the system, meaning this will not benefit from the experience and "flexibility in business" of the human factor, in order to perform an accurate analysis or to take the optimal decisions.

In other words, DSS should offer the capability to: identify the issue situation; collect and analyze data; establish the causes of an issue; redefine the objectives; generate alternative solutions; compare and to evaluate alternative solutions; chose the optimal solution. DSS should also offer to decision matters the information stored together with a description of both the external competition environment, as well as the way enterprise caries out activities.

The subsystem of underlying the decision and simulating the alternative solutions should respond on the automatic reprogramming, basing on conflict analysis and by using one of the planning-reprogramming strategies. The decision should take into account the execution delays, and should be able to anticipate the potential distortions that might influence the requirement's concluding. The protocol includes a series of interactive steps, by sending messages of recommendation towards providers, by issuing new solutions of making efficient the production process, of selecting partners and of reprogramming the procedures of maintaining the delivering data, as well as real time evaluation of the partial results. There are various possibilities of reprogramming, as following: automatic, semi-automatic and manual. A potential conflict should affect at the very most the BP, under the responsibility of provider under discussion, and only slightly the other VE members.

The Conflict Detection Subsystem is an entity which receives information regarding the production, and it is permanently supervised, in order to check the information accuracy on planning or established terms on deliveries, as well as the execution stages. In the case a conflict is detected, this will be identified and transferred towards the module of taking decisions as answer on those detected.

The control subsystem performs a series of actions as regards the carrying into effect a decision chosen as alternative solution. The user of the VE coordination website will work together with DBPM (regarded as DSS, also) and will be able to simulate an extended set of alternative decisions.

The contract provided within a VE scenario will specify the rights and obligations within the relationships established by enterprises (clauses including the judicial, technical and financial information) and moreover, the responsibilities towards conventional systems, the clauses of supervision (access to information, in the view of monitoring it). The cooperation between enterprises regards the agreement or consensus over the set of information to be provided, so that the remote supervision will be enabled.

Customizing the supervision clauses signifies one of the first procedures than a user should apply immediately after a VE is formed. The user should specify periodically reported information (for instance, the manufacturing data, the produced quantities, the demands status, the information transparency, transferring decisions and in parallel, supplementary documentations or sending the supervision data).

It is important to give some examples of Virtual Breeding Environments (VBEs) as the following: Virtuelle Fabrik (consortium in machine building sector between Switzerland and Germany); Swiss Microtech (micromechanics, collaboration with China); ISOIN (aeronautical cluster); CeBeNetwork (integrated portfolio for aeronautical engineering between France, UK and Germany); ConSEN Euro – Group (cluster of European SMEs in Information Society Technologies); Infranet – Partners (network of SMEs in Internet solution domain). As Professional Virtual Communities (PVCs) we can take into consideration the following examples: Projectwerk (4000 freelancers and SMEs); Elance; freelancer; associations of professionals etc.

http://dx.doi.org/10.5772/3371

5. Conclusions and future work

The current situation in the aftermath of the global crisis and the European debt crisis, markets are highly volatile and very sensitive to the social, political, economical, business, technical, organizational but also other factors dealing with the workforce. The success of a VE solution depends heavily on innovation (including innovation on management) since they are market-oriented organizations. These vehicles should react quickly and reconfigure to satisfy new market demands and customer trends in an agile manner.

Although ontologies specifically for VEs have not been addressed, we believe that ontologies for enterprises, in general, will address issues that need to be addressed by VE ontologies too. It is important to highlight that the need for ontology is mostly due to information exchange among people and computers and to support interoperability, which is one of the most important issues in VEs.

The modern business environment has been characterized by the networking interconnection, the cooperation related to disrupted technologies, where one might emphasize the interest growth on intelligent platforms of common architecture, able to provide valuable elements. The intelligent coordination will require taking into account the entire SCM, within an intelligent organizational environment (Pereira, Klen, 2000).

The modern enterprise should benefit from new, intelligent, adaptive instruments of decision, capable to: solve complex problems; to realize efficient interconnection/ interoperation (modularity); to offer efficient/ quick solutions for the distributed problems in a more and more complex environment with highly volatile markets; to integrate, fuse and filter information from different, distributed informational sources; to offer better performances (speed, security, expandability to operate with information and knowledge); to offer better clarity and simplicity in analysis; to offer scalability and, in general adaptability of the application for an optimal use of resources.

DSS is more than informational product that implement a method for decision making. DSS is based on multitude components in interaction and it integrates informatics modules but also specific techniques for decisions, and communications. The main characteristics of DSS are: applicability, expected benefits, utility and relevance, addressability. The AI ingredients, such as the expert systems, the knowledge based systems, learning abilities networks have been underlying on different types of AI technologies and coul offer better performance on mixing with DSS.

The DSS-VE/VO offers advanced coordination facilities, able to support the means of achieving, providing and managing the information related to production within VE/ VO. This system will embed the SCM and ILM concepts in the context of Integrated Logistics Management (ILM). This system should be modular, allowing to enterprises to operate better within an integrated virtual environment, underlying on subsystems of supervision or monitoring the DBP and DSS execution, meaning the configuration of the supervising provision.

The DSS-VE/VO systems will allow efficient tasks regarding: the supervision of SCM demands, underlying on the supervision clauses associated to contracts; the interactive support on analyzing and solving the conflicts on processing demands by taking reactive decisions; the partners' configuration; the support on re-planning share by means of the basic programming actions within VE; integration with the cooperation platform (data integration; security communications; inter-functionality or interaction). Taking into account the complexity of DSS-VE/VO systems, innovative issues should be investigated, especially towards the line of intelligent coordination.

The future developments of the concepts linked to VE (new assessment models based on ability to add real value, changes in the competition nature between firms, new possibilities for integration/ mixing with DSS) should consider the following future directions of research: the development of VE platforms dedicated for SMEs and startups; the specification of operational characteristics and the analysis of the distributed architectures; the development of the new methods of management, coordination, cooperation and negotiations between VEs; special focus on social aspects regarding the development of VEs. Other aspects to cover in future work should take into account: the coordination functionalities such as distributed resource management and scheduling and the new role of negotiation in a VE as a central task in the formation of a VE/ VO but also in the operation and success of these innovative vehicles.

Author details

Gabriela Prelipcean[1] and Mircea Boscoianu[2]

1 Stefan cel Mare University of Suceava, Romania

2 Henri Coanda Air Force Academy of Brasov, Romania

References

[1] Afsarmanesh, H., Camarinha-Matos, L.M., 2000, A virtual tourism enterprise, Proceedings of WISE 2000 – 1st ACM/IEEE International Conference on Web Information Systems Engineering, Vol. 1, IEEE Computer Society Press, Hong Kong.

[2] Afsarmanesh, H., Camarinha-Matos, LM, 2005. A Framework for Management of Virtual Organization Breeding Environments. 6TH ifip working conference on virtual enterprises, PROVE-05, Valencia, Spain.

[3] Alexakis, S., Kolmel, B., Heep, T., 2004, VO in Industry: State of the Art, in Collaborative Networked Organizations: A Research Agenda for Emerging Business Models", Kluwer.

[4] Ambroszkiewicz, S., Cetnarowicz, K., Radko, B., 1998, Enterprise Formation Mechanisms based on Mobile Agents, In Holsten, A. et al. (eds.), Proc. of the Workshop on Intelligent Agents in Information and Process Management, KI'98, TZI-Bericht, No.9.

[5] Baldo, f., Rabelo, R.J., Vallejos, R.V., 2008, Modeling Performance Indicators' Selection Process for VO Prtners' Suggestions, in Proceedings BASYS'2008 – 8th IFIP Int. Conf. on Information Technology for Balance Automation Systems, pp.67-76, Springer, Heilderberg.

[6] Bernus, P., Nemes, L., 1996, A framework to define a generic enterprise reference architecture and methodology, Computer-Integrated Manufacturing Systems, vol.9, no.3.

[7] Bowersox, D.J., Closs, D.J., Helferich, O.K., 1986, Integration of phisical distribution, materials management and logistical coordination, New York, NY: Macmilan.

[8] Brazier F.M.T., Jonker C.M., Treur J., 2002, Principles of component-based design of intelligent agents. Data and Knowledge Engineering, 41.

[9] Brazier, F. M. T., Dunin-Keplicz, B. M., Jennings, N. R. and Treur, J., 1997, DESIRE: Modelling Multi-Agent Systems in a Compositional Formal Framework. Int. Journal of Cooperative Information Systems, 6, (1).

[10] Byrne, J. A., Brandt, R. and Port, O., 1993, The virtual corporation: the company of the future will be the ultimate in adaptability, Business Week.

[11] Camarinha-Matos, LM and Afsarmanesh, H., 2005, Brief historical perspective for virtual organizations, Virtual Organizations Systems and Practices, Springer, New York, USA.

[12] Camarinha-Matos, LM. and Afsarmanesh, H., 2003, Elements of a base VE infrastructure, Journal of Computers in Industry, Volume 51, Issue 2.

[13] Camarinha-Matos, LM., Afsarmanesh, H., Ollus, M., 2005, Ecolead: A Holistic Approach to Creation and Management of Dynamic Virtual Organizations, in collab. Networks and Their Breeding Environments, Springer, Heilderberg.

[14] Camarinha-Matos, LM; Afsarmanesh, H., 2005, Collaborative networks: A new scientific discipline, In Journal of. Intelligent Manufacturing.

[15] Camarinha-Matos, L.M. and Afsarmanesh, H., 2001, Virtual enterprise modelling and support infrastructures: applying multi-agent system approaches, in M. Luck et al. (Eds.) Multi-agent Systems and Applications, Springer-Verlag.

[16] Camarinha-Matos, LM., Afsarmanesh, H., 1999, The virtual enterprises Concept. In Infrastructures for Virtual Enterprises: networking industrial enterprises, US: Kluwer Academic Publishers.

[17] Camarinha-Matos, L.M., Afsarmanesh, H., Garita, C., Lima, C., 1998, Towards an architecture for virtual enterprises, The Journal of Intelligent Manufacturing, Vol. 9, Issue 2.

[18] Castelfranchi C., Falcone R., 1998, Towards a theory of delegation for agent-based systems, Robotics and Autonomous Systems, 24 (3-4).

[19] Clements, P. E., Papaioannou, T., Edwards. J., 1997, Aglets: Enabling the Virtual Enterprise, In Wright, D et al. (Eds.), Proc. of Mesela '97 - 1st Int'l Conf. on Managing Enterprises - Stakeholders, Engineering, Logistics and Achievement. Mechanical Engineering Publications Ltd.

[20] Cunha, M.M., Putnik, G.D., Carvalho, J.D. and Avila P., A review of environments supporting virtual enterprise integration, Knowledge and technology integration in production and services, Fifth IFIP international Conference on Information technology for Balanced Automation Systems in Manufacturing and Services, Kluwer Academic Publishers, 2002, Cancun, MX.

[21] Cristopher, M.L., 1994, Logistics and supply chain management, Pitman Publishing, London.

[22] Christopher, M., 1994, New directions in Logistics, Logistics and Distribution Planning – strategies for management, ed. by James Cooper, Kogan Page Limited, 2nd edition.

[23] Davidow, W.H., Malone, M.S., 1992, The Virtual Corporation: Structuring and Revitalising the Corporation for the 21st Century, Harper Business.

[24] Dorn, J. Hrastnik, P. and A. Rainer, 2004, Conferences as Virtual organization, Virtual Enterprises and Collaborative Environments, IFIP 5th working conference on virtual enterprises, Kluwer Academic Publishers, Toulouse, France.

[25] Drissen-Silva, M.V., Rabelo, R.J., 2009, A Collaborative Decision Support Framework for Managing the Evolution of Virtual Enterprises, International Journal of Production Research, 47 (17).

[26] Ferber, J., Gutknecht, O., 1998, A meta-model for the analysis and design of organizations in multi-agent systems. In Proceedings of the 3nd International Conference on Multi-Agent Systems (ICMAS-98).

[27] Ferreira, D., Goletz, T. and Ferraz, R., 2000, A workflow-based approach to the integration of enterprise networks, Proceedings CARS& FOF 2000, Port of Spain, Trinidad.

[28] Fischer, K., Muller, J. P., Heimig, I., Scheer, A., 1996, Intelligent Agents in Virtual Enterprises, Proceedings of the First International Conference and Exhibition on The Practical Applications of Intelligent Agents and Multi-Agent Technology, April 1996, London, U.K.

[29] Fox, M.S., Chionglo, J.F. Barbuceanu, M., 1993, The Integrated Supply Chain Management System, University of Toronto, Enterprise Integration Laboratory, Toronto.

[30] Franke, U., 2001, The Concept of Virtual Web Organizations and Its Implications on Changing Market Conditions, Electronic Journal of Organizational Virtualness, Vol. 3 No.4.

[31] Fu, K.S., 1970, Learning Control Systems--Review and Outlook, IEEE Transactions on Automatic Control, No. 15.

[32] Gadomski, A. M., Bologna, S., Di Constanzo, G., Perini, A., Schaerf, M., 2001, Towards intelligent decision support systems for emergency managers: the IDA approach, International Journal Risk Assessment and Management, vol.2, no. 3-4.

[33] Holland, J.H., 1975, Adaptation in Natural and Artificial Systems, University of Michigan Press, Ann Harbor, MI.

[34] Holsaplle, C. W., Whinston, A. B., 1996, Decision Support Systems: A Knowledge-based Approach, West Publishing Company, Minneapolis/St Paul.

[35] Ivanov, D., Arkhipov, A. and Sokolov, B., 2003, Intelligent planning and control of manufacturing supply chains in virtual enterprises, in Proceeding of PRO-VE'03 – Processes and Foundations for Virtual Organizations, Kluwer Academic Publishers, Switzerland.

[36] Jain, A. K., Aparicio IV, M., Singh, M. P., 1999, Agents for Process Coherence in Virtual Enterprises, In Communications of the ACM, March, Vol. 42, No. 3.

[37] Jansson, K., Eschenbacher, J., 2005, Challenges in Virtual Organisations Management – Report on methods for distributed business process management. Tech. Report D32.1. European Collaborative networked Organizations LEADership initiative. FP6 IP 506958.

[38] Janssen, T. L., 1989, Network expert diagnostic system for real-time control, Proceedings of the second international conference on industrial and engineering applications of artificial intelligence and expert systems, Vol. 1 (IEA/AUIE '89).

[39] Katzy, B. R., Schuh, G., 1997, The Virtual Enterprise, in: Molina, A., Sanchez, J. M., Kusiak, A. (eds.), Handbook of Life Cycle Engineering: Concepts, Methods and Tools, New York, Chapman & Hall.

[40] Kazi, A.S., Hannus, M., 2002, Virtual enterprise reference architecture and methodology, eWork and eBusiness in AEC, ECPPM 2002, Slovenia.

[41] Kerschberg, L., 1997, Knowledge rovers: Cooperative intelligent agent support for enterprise information architectures, in P. Kandzia and M. Klusch, Eds., Cooperative Information Agents, First International Workshop, CIA'97, Kiel, Germany, Proceeding, Springer-Verlag.

[42] Kim, C., Son, Y., Kim, T., Kim, K., 2004, A modeling approach for designing a value chain of VE. Virtual Enterprises and collaborative Environments, IFIP 5th working conference on virtual enterprises, Kluwer Academic Publishers, Toulouse, France.

[43] Little, J. D.C., 1970, Models and Managers: The Concept of a Decision Calculus, Management Science, 6, No. 8.

[44] Lopes Cardoso, L., Malucelli, A., Rocha, A.P., Oliveira, E., 2005, Institutional Services for Dynamic Virtual Organizations, In 6th IFIP working conference on virtual enterprises (PRO-VE'05), Valencia, Spain.

[45] Lopes Cardoso, L., Oliveira, E., 2004, Virtual Enterprise Normative Framework Within Electronic Institutions, In Proceedings of the Fifth International Workshop Engineering Societies in the Agents World (ESAW'04), Toulouse, France.

[46] Loss, L., Pereira-Klen, A.A., Rabelo, R.J., 2006, Virtual Organization Management: An Approach Based on Inheritance Information. In Global conference on Sustainable Poduct Deelopment and Life Cycle Engineering. Oct.03-06, Sao Carlos, SP, Brazil.

[47] Luczak et. al., 2005, Realization of the Virtual Enterprise Paradigm in the clothing industry though e-business technology, Virtual Organizations Systems and Practice.

[48] Malhotra, Y., 2000, Knowledge Management and Virtual Organizations, Idea Group Publishing, USA.

[49] Meystel, A.M., Albus, J.S., 2002, Intelligent System: architecture, design and control, John Wiley and Sons.

[50] Negretto, H., Hodik, J., Mulder, W., Ollus, M., Pondrelli, P., Westphal, I., 2008, VO Management Solutions: VO management e-services, in Methods and Tools for Collaborative.Netwoked Organisations, Springer, Heilderberg.

[51] Norman, R., Ramirez, R., 1993, From Value Chain to Value Constellation: Designing Interactive Strategy, Harvard Business Review.

[52] Oliveira, E., Rocha, A.P., 2000, Agents advanced features for negotiation in electronic commerce and virtual organisation formation process, European Perspectives on Agent-Mediated Commerce, Springer-Verlag.

[53] Petersen, S.A., Gruninger, M., 2000, An agent-based model to support the formation of virtual enterprises', International ICSC Symposium on Mobile Agents and Multiagents in Virtual organisations and E-Commerce (MAMA'2000), Wollongong, Australia.

[54] Prelipcean G., Boscoianu M., 2008, An innovative decision support system for strategic investments in power sector, WSEAS TRANSACTIONS on POWER SYSTEMS, ISSN 1790-5060, Issue 6, volume 3, June 2008.

[55] Prelipcean G., Boscoianu M., 2008, Computational framework for assessing decisions in energy investments based on a mix between real options analysis and artificial neural networks, in Proceedings of the 9th WSEAS International Conference on Mathematics & Computers in Business and Economics (MCBE'80).

[56] Rabelo, R., F Baldo, F., Tramontin, R.J., 2004, Smart configuration of dynamic virtual enterprises, Virtual Enterprises and collaborative Environments, IFIP 5th working conference on virtual enterprises, Kluwer Academic Publishers, Toulouse, France.

[57] Rabelo, R.J., Camarinha-Matos, L.M., Vallejos, R., 2000, Agent-based brokerage for virtual enterprise creation in the moulds industry, in E-business and Virtual Enterprises, Kluwer Academic Publishers.

[58] Rabelo, R. J. Camarinha-Matos, L.M., 1996, Towards Agile Scheduling in Extended Enterprise. In Balanced Automation Systems II - Implementation Challenges for Anthropocentric Manufacturing. (Luis M. Camarinha-Matos and Hamideh Afsarmanesh, (Eds.)), Chapman & Hall.

[59] Rabelo, R.J., Camarinha-Matos, L.M., 1994, Negotiation in multi-agent based dynamic scheduling, International Journal on Robotics and CIM, Vol.11(4).

[60] Rocha, A., Oliveira, E., 1999, An electronic market architecture for the formation of virtual enterprises, in Infrastructures for Virtual Enterprises, Kluwer, Boston.

[61] Slats, P. A., 1995, Logistics Chain Modeling, European Journal of Operational Research, No. 87.

[62] Shen, W., Norrie, D., 1999, Agent-Based Systems for Intelligent Manufacturing: A State of the Art Survey, International Journal of Knowledge and Information Systems 1(2).

[63] Szirbik, N. B., Hammer, D. K., Goossenaerts, J. B. M., Aerts, A. T. M., 1999, Mobile Agent Support for Tracking Products in Virtual Enterprises, AGENT'99, Seattle, USA, May, Workshop Notes, ACM.

[64] Stone, P., Veloso, M., 2000, Multiagent Systems: A Survey from a Machine Learning Perspective, Autonomous Robots, Volume 8, No. 3.

[65] Tølle, M., Bernus, P., 2003, Reference models supporting enterprise networks and virtual enterprises, International Journal of Networking and Virtual Organisations, Vol. 2, No. 1.

[66] Tsakopoulos, S., Bokma, A., Plekhanova, V., 2003, Partner evaluation and selection in virtual enterprises using a profile theory based approach, in Proceeding of PRO-VE’03 – Processes and Foundations for Virtual Organizations, Kluwer Academic Publishers, Switzerland.

[67] Venkatraman, N., Henderson, C., 1998, Real Stategies for Virtual Organising, Sloan Management Review, Issue 40.

[68] Vernadat, F. B., 1996, Enterprise Modeling and Integration Principles and Applications, Chapman and Hall Publishers.

[69] Wigand, R., Picot, A., Reichwald, R., 1998, Information, Organization and Management: Expanding Markets and Corporate Boundaries, Chichester: John Wiley and Sons.

[70] Wildeman, L., 1998, Alliances and networks: the next generation, International Journal Technology Management, Vol. 15.

[71] Wognum, P.M., Faber, C., 2003, Infrastructures for collaboration in virtual organizations, Int. Journal of Computer Applications in Technology, Geneva, Vol. 18, Issue 1-4.

[72] Zweger, A., Tolle, M., Vesterager, J., 2002, VERAM: Virtual Enterprise Reference Architecture and Methodology, Global Engineering and Manufacturing in Enterprise Networks GLOBEMEN, eds. I. Karvonen et. al., Julkaisija Utgivare Publisher, Finland.